$$\frac{\sum_{k=2}^{\infty}\left(a_k{}^2+b_k{}^2\right)}{a_1{}^2+b_1{}^2}.$$

Clearly, this quantity is most easily computed in the frequency domain. However, the numerator equals the square of the signal's rms value minus the power in the average and the power in the first harmonic.

Solution to Exercise 4.5.1

Total harmonic distortion in the square wave is

$$1-\frac{1}{2}\left(\frac{4}{\pi}\right)^2=20\%.$$

Solution to Exercise 4.6.1

N signals directly encoded require a bandwidth of

$$\frac{N}{T}$$

. Using a binary representation, we need

$$\frac{log_2 N}{T}$$

. For ***N = 128***, the binary-encoding scheme has a factor of

$$\frac{7}{128}=0.05$$

smaller bandwidth. Clearly, binary encoding is superior.

Solution to Exercise 4.6.2

We can use N different amplitude values at only one frequency to represent the various letters.

Solution to Exercise 4.7.1

Because the filter's gain at zero frequency equals one, the average output values equal the respective average input values.

Solution to Exercise 4.8.1

$$F(S(f))=\int_{-\infty}^{\infty}S(f)e^{-(j2\pi ft)}df=\int_{-\infty}^{\infty}S(f)e^{+j2\pi f(-t)}df=s(-t)$$

Solution to Exercise 4.8.2

$$F(F(F(F(s(t)))))=s(t)$$

. We know that *F (S (f)) =*

$$F(S(f))=\int_{-\infty}^{\infty}S(f)e^{-(j2\pi ft)}df=\int_{-\infty}^{\infty}S(f)e^{+j2\pi f(-t)}df=s(-t)$$

s (−t). Therefore, two Fourier transforms applied to s (***t***) yields s (−***t***). We need two more to get us back where we started.

Solution to Exercise 4.8.3

The signal is the inverse Fourier transform of the triangularly shaped spectrum, and equals

s\left (t \right)=W\left (\frac{sin(\left \pi Wt \right)}{\pi W t} \right)^2